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jc890 U.S. PTO 09/26/00

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PTO/SB/05 (4/98)
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Patent and Trademark Office. U.S. DEPARTMENT OF COMMERCE

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No.	ATI-000150BT
First Inventor or Application Identifier	Feliks Dujmenovic
Title	IMAGE REJECTION MIXING IN WIDEBAND APPLICATIONS
Express Mail Label No.	EL703379723US

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents

ADDRESS TO: **Commissioner for Patents, Box Patent Application, Washington, DC 20231**

jc675 U.S. PTO 09/669274 09/26/00

1. [X] * Fee Transmittal Form *(e.g., PTO/SB/17)* *(Submit an original and a duplicate for fee processing)*
2. [X] Specification [*Total Pages* 10] *(preferred arrangement set forth below)*
   - Descriptive title of the Invention
   - Cross References to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to Microfiche Appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings (*if filed*)
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
3. [X] Drawing(s) *(35 U.S.C. 113)* [*Total Sheets* 2]
4. Oath or Declaration [*Total Pages* 2]
   - a. [X] Newly executed (original or copy)
   - b. [ ] Copy from a prior application (37 C.F.R. § 1.63(d)) *(for continuation/divisional with Box 16 completed)*
     - i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).

NOTE FOR ITEMS 1 & 13: IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).

5. [ ] Microfiche Computer Program *(Appendix)*
6. Nucleotide and/or Amino Acid Sequence Submission (*if applicable, all necessary)*
   - a. [ ] Computer Readable Copy
   - b. [ ] Paper Copy (identical to computer copy)
   - c. [ ] Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

7. [X] Assignment Papers (cover sheet & document(s))
8. [ ] 37 C.F.R.§3.73(b) Statement *(when there is an assignee)* [ ] Power of Attorney
9. [ ] English Translation Document *(if applicable)*
10. [ ] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
11. [ ] Preliminary Amendment
12. [X] Return Receipt Postcard (MPEP 503) *(Should be specifically itemized)*
13. [ ] * Small Entity Statement(s) *(PTO/SB/09-12)* [ ] Statement filed in prior application, Status still proper and desired
14. [ ] Certified Copy of Priority Document(s) *(if foreign priority is claimed)*
15. [ ] Other: ....

16. If a CONTINUING APPLICATION, *check appropriate box, and supply the requisite information below and in a preliminary amendment:*

[ ] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No: ______

Prior application information: *Examiner* ______ *Group / Art Unit:* ______

For CONTINUATION or DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

17. CORRESPONDENCE ADDRESS

[X] *Customer Number or Bar Code Label* 25310 *(Insert Customer No. or Attach bar code label here)* *or* [ ] *Correspondence address below*

Name	Volpe and Koenig, P.C. DEPT ATI				
Address					
City		*State*		*Zip Code*	
Country		*Telephone*		*Fax*	

Name (Print/Type)	Kao H. Lu, Esquire	*Registration No (Attorney/Agent)*	43,761
Signature	[signature]	*Date*	9/26/00

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FEE TRANSMITTAL for FY 2000

Patent fees are subject to annual revision.
Small Entity payments must be supported by a small entity statement, otherwise large entity fees must be paid. See Forms PTO/SB/09-12. See 37 C.F.R §§ 1.27 and 1.28.

TOTAL AMOUNT OF PAYMENT ($) 690.00

Complete if Known	
Application Number	Not Yet Known
Filing Date	Not Yet Known
First Named Inventor	Feliks Dujmenovic
Examiner Name	Not Yet Known
Group / Art Unit	Not Yet Known
Attorney Docket No.	ATI-000150BT

METHOD OF PAYMENT (check one)

1. [X] The Commissioner is hereby authorized to charge indicated fees and credit any over payments to:

Deposit Account Number: 50-0441

Deposit Account Name: ATI Technologies Inc.

[X] Charge Any Additional Fee Required Under 37 CFR §§ 1.16 and 1.17

2. [ ] **Payment Enclosed:** [ ] Check [ ] Money Order [ ] Other

FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
101	690	201	345	Utility filing fee	690
106	310	206	155	Design filing fee	
107	480	207	240	Plant filing fee	
108	690	208	345	Reissue filing fee	
114	150	214	75	Provisional filing fee	

SUBTOTAL (1) ($) 690.00

2. EXTRA CLAIM FEES

			Extra Claims		Fee from below		Fee Paid
Total Claims	15	- 20** =	0	X	18	=	0
Independent Claims	3	- 3** =	0	X	78	=	0
Multiple Dependent						=	0

***or number previously paid, if greater; For Reissues, see below*

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
103	18	203	9	Claims in excess of 20
102	78	202	39	Independent claims in excess of 3
104	260	204	130	Multiple dependent claim, if not paid
109	78	209	39	** Reissue independent claims over original patent
110	18	210	9	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($) 0.00

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet.	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for reply within first month	
116	380	216	190	Extension for reply within second month	
117	870	217	435	Extension for reply within third month	
118	1,360	218	680	Extension for reply within fourth month	
128	1,850	228	925	Extension for reply within fifth month	
119	300	219	150	Notice of Appeal	
120	300	220	150	Filing a brief in support of an appeal	
121	260	221	130	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive - unavoidable	
141	1,210	241	605	Petition to revive - unintentional	
142	1,210	242	605	Utility issue fee (or reissue)	
143	430	243	215	Design issue fee	
144	580	244	290	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Petitions related to provisional applications	
126	240	126	240	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	
146	690	246	345	Filing a submission after final rejection (37 CFR § 1.129(a))	
149	690	249	345	For each additional invention to be examined (37 CFR § 1.129(b))	

Other fee (specify) ______________________

Other fee (specify) ______________________

* Reduced by Basic Filing Fee Paid

SUBTOTAL (3) ($) 0.00

SUBMITTED BY				Complete *(if applicable)*	
Name (Print/Type)	Kao H. Lu, Esquire	*Registration No. (Attorney/Agent)*	43,761	*Telephone*	215-568-6400
Signature	[signature]			*Date*	9/26/00

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IMAGE REJECTION MIXING IN WIDEBAND APPLICATIONS

BACKGROUND

This invention generally relates to wideband communication systems. In particular, the invention relates to image suppression in received wideband communications.

Wideband communication systems, such as television and radio communication systems, use a wide frequency spectrum to communicate information. Typically, the wide spectrum is divided into a group of assigned radio frequencies for carrying the information.

In a heterodyne receiver, the received signal is amplified by a radio frequency (RF) amplifier and mixed with an adjustable local oscillator (LO) signal to produce intermediate frequency (IF) signal. One problem with mixer circuits is the generation of image frequency signals.

When two signals are mixed, signal components are produced at the sum and difference of the two signals, and their harmonics. Equation 1 illustrates the potential signal components where F_{LO} is a local oscillator frequency being mixed with a radio frequency, F_{RF} and m and n are integers or zero.

$$\pm m F_{RF} \pm n F_{LO} \qquad \text{Equation 1}$$

Since input circuits typically have limited selectivity in the mixing process, undesired interference may create harmful products, as illustrated by Equation 2. F_I is an undesired interference frequency and m, n and p are an integer or zero.

$$\pm m F_{RF} \pm n F_{LO} \pm p F_I \qquad \text{Equation 2}$$

For example, when an intermediate frequency signal, F_{RF}, is mixed with a local oscillator, F_{LO}, the result will produce signals at two frequencies, $F_{LO} + F_{RF}$ and $F_{LO} - F_{RF}$. One of the two signals is the desired frequency and the other is at an undesired frequency. Additionally, based on the quality of the mixers, undesirable harmonics, such as $F_{LO} + 2F_{RF}$, could also be produced. In a wideband communication system utilizing multiple frequencies, the frequencies that these undesired signals fall upon may be the same frequency used for another information signal. As a result, the undesired signal produces an image on the desired information signal at that frequency.

One approach to removing the image signal from the desired signal is by filtering. Typically, filtering only reduces the magnitude of the image signal by less than 30 decibels (dB). In some applications, a 30 dB attenuation is not sufficient.

Another approach is to use an image rejection mixer 10, as illustrated in Figure 1. A received radio frequency signal is input into the image rejection mixer 10. The received signal is input to an in-phase mixer 14 and a quadrature phase mixer 12. A local oscillator (LO) 11 generates a carrier signal. The carrier signal is input into the quadrature phase mixer 12 to produce a demodulated quadrature phase signal and into a 90 degree phase shift device 16, such as a RC–CR circuit, to produce an in-phase carrier. The in-phase carrier is input into the in-phase mixer 12 to produce a demodulated in-phase signal. The demodulated quadrature phase signal is subsequently delayed by a 90 degree phase shift device 22. An adder 20 combines the phase delayed quadrature phase signal to the in-phase signal to produce the desired signal. Typically, the image signal will be out of phase with the desired signal. As a result, the combining cancels the image signal leaving only the desired signal.

To illustrate, W_{RF} is the frequency of the received signal and W_{LO} is the frequency at the local oscillator. The image rejection mixer 10 processes the desired signal as follows. I(t) is the demodulated in-phase signal. Q(t) is the demodulated quadrature phase signal. Q'(t) is the phase delayed quadrature phase signal. O(t) is the subtracted signal.

$$I(t) = \cos(W_{RF}t) * \cos(W_{LO}t) =$$
$$= \tfrac{1}{2}[\cos(W_{RF} - W_{LO})t + \cos(W_{RF} + W_{LO})t], \text{ where } W_{RF} - W_{LO} > 0$$

Equation 3

The $\cos(W_{RF} + W_{LO})t$ is removed by low-pass filtering.

$$Q(t) = \cos(W_{RF}t) * \cos(W_{LO}t - \pi/2) =$$
$$= \tfrac{1}{2}\cos[(W_{RF} - W_{LO})t + \pi/2] = -\tfrac{1}{2}\sin(W_{RF} - W_{LO})t$$

Equation 4

$$Q'(t) = -\tfrac{1}{2}\sin[(W_{RF} - W_{LO})t - \pi/2] = \tfrac{1}{2}\cos(W_{RF} - W_{LO})t$$

Equation 5

$$O(t) = I(t) + Q'(t) = \cos(W_{RF} - W_{LO})t$$

Equation 6

The image rejection mixer 10 processes the image signal which is inverted with respect to the desired signal as follows.

$$I(t) = \tfrac{1}{2}\cos[-(W_{RF} - W_{LO})t] = \tfrac{1}{2}\cos(W_{RF} - W_{LO})t$$

Equation 7

$$Q(t) = \tfrac{1}{2}\cos[-(W_{RF} - W_{LO})t + \pi/2] = \tfrac{1}{2}\sin(W_{RF} - W_{LO})t$$

Equation 8

$$Q'(t) = \tfrac{1}{2}\sin[(W_{RF} - W_{LO})t - \pi/2] = -\tfrac{1}{2}\cos(W_{RF} - W_{LO})t$$

Equation 9

$$O(t) = I(t) + Q'(t) = \tfrac{1}{2}\cos(W_{RF} - W_{LO})t - \tfrac{1}{2}\cos(W_{RF} - W_{LO})t = 0$$

Equation 10

Accordingly, after image cancellation, the desired signal is recovered, Equation 6, and the image signal is canceled, Equation 10.

Due to variations in the tolerances of the resistors and capacitors in the phase shift device 16 and temperature variations, the phase differential between the carrier and the quadrature carrier may not be maintained at an ideal 90 degrees, degrading performance of the image mixer.

Accordingly, it is desirable to have alternate approaches for image suppression in received wideband signals.

SUMMARY

A ring oscillator produces an in-phase and quadrature phase radio frequency signal. A first mixer mixes the in-phase signal with a received signal. A second mixer mixes the quadrature phase signal with the received signal. A combiner, operatively coupled to the first and second mixers, produces an image cancelled signal.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an image rejection mixer.

Figure 2 is an image rejection mixer using a ring oscillator.

Figure 3 is a delay cell.

Figure 4 is a RC-CR circuit.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

Figure 2 illustrates an image rejection mixer 24 for use in a wideband communication system receiver, such as a television tuner or radio tuner. Although the image rejection mixer 24 is shown using balanced mixers 28, 30, such as a Gilbert cell, other mixers may be used. Balanced mixers are desirable due to their noise suppression quality. A received RF signal is buffered by a buffer 58 so that the RF signal as outputted by the buffer 58 is shifted to a desired level for the in-phase and quadrature mixers 30, 28. The buffered RF signal is inputted into both the in-phase and quadrature phase mixers 30, 28. A ring oscillator 32 produces an in-phase carrier which is input into the in-phase mixer 30 and a quadrature phase carrier which is input to the quadrature

phase mixer 28. The demodulated quadrature phase signal is subsequently delayed by a 90° phase delay device 38, such as an RC–CR circuit. The delayed quadrature phase signal is combined using an adder 40 to the in-phase signal to produce the desired signal with the image signal cancelled.

By using the ring oscillator 32, the in-phase and quadrature carrier are maintained at a near ideal 90 degree phase difference. Since the demodulated signals are at low frequencies, a simpler 90 degree phase shift device 38, such as an RC-CR circuit, may be used without degrading the image rejection mixer's performance. Using the ring oscillator 32, a 60 dB attenuation in the image signal is achieved.

One ring oscillator 32 for producing the in-phase and quadrature phase carrier uses four delay cells 44_1-44_4, as shown in Figure 2. Each delay cell 44_1-44_4 delays the input signal by 45 degrees. As a result, the first delay cell 44_1 produces a 45 degree phase delay. The second delay cell delays the 45 degree delayed signal by another 45 degrees, totaling 90 degrees. The output of the second delay cell 44_2 is inverted as to shift the phase by 180 degrees prior to being input into the third delay cell 44_3. The third delay cell 44_3 delays the 270 degree delayed signal by 45 degrees, totaling 315 degrees. The fourth cell 44_4 delays the output of the third cell 44_3 by 45 degrees totaling 360 degrees creating the oscillation. Although the output of the second cell 44_2 is shown as used for the in-phase carrier and the output of the fourth cell 44_4 for the quadrature phase carrier, any of the outputs or inputs separated by 90 degrees may be used.

One circuit for use as a delay cell 44_1-44_4 is shown in Figure 3 using CMOS circuitry. Six n-type MOSFETS 46_1-46_6 and two p-type MOSFETS 48_1, 48_2 are configured as shown in Figure 3. The inputs to the gates of the two bottom n type MOSFETS 46_1, 46_2 are connected in series to form the bias, control frequency, to the delay cells 44_1-44_4. The gates of the two lower n type MOSFETS 46_3, 46_6 form the input of the delay cells 44_1-44_n. The drains of those MOSFETS 46_3, 46_6, form the output. This CMOS circuit produces an output having a phase delayed by 45 degrees from the input.

A simple 90 degree phase shift device 38 may be used for the quadrature phase demodulated signal, such as a RC-CR circuit as shown in Figure 4. The demodulated

quadrature phase signal is input into the delay device 38. The input of the delay device 38 is coupled to a series connected resistor 50 and capacitor 52 connected in parallel to a series connected capacitor 54 and resistor 56. An output of 90 degrees of phase delay is produced at the nodes between the series connected resistors 50, 56 and capacitors 52, 54.

*　　　　*　　　　*

CLAIMS

What is claimed is:

1. An apparatus for canceling an image signal from a received radio frequency signal, the apparatus comprising:

a ring oscillator for producing a radio frequency signal having in-phase and quadrature phase components;

a first mixer having inputs configured to receive the in-phase component and the received radio frequency signal and outputting an in-phase signal;

a second mixer having inputs configured to receive the quadrature phase component and the received radio frequency signal and outputting a quadrature phase signal;

a phase shift device coupled with one of the mixers for receiving an output of the one mixer and outputting a phase shifted signal; and

a combiner, operatively coupled to the other of the mixers and said phase shift device, for producing an image cancelled signal.

2. The apparatus of claim 1 wherein the phase shift device is coupled to the second mixer.

3. The apparatus of claim 2 wherein the phase shift device shifts a phase of the second mixer output by ninety degrees.

4. The apparatus of claim 1 wherein the ring oscillator comprises four delay cells, an output of each delay cell is coupled to an output of another of the delay cells.

5. The apparatus of claim 4 wherein each delay cell delays its input by forty-five degrees and one of the couplings is cross-coupled so that the output of one of the delay cells is inverted prior to input into another of the delay cells.

6. The apparatus of claim 1 wherein the first mixer and the second mixer are gilbert cells.

7. A receiver for use in a wideband communication system, the receiver capable of canceling an image signal from a received radio frequency signal, the receiver comprising:

a ring oscillator for producing a radio frequency signal having in-phase and quadrature phase components;

first mixing means for mixing the in-phase component with the received radio frequency signal and outputting an in-phase signal;

second mixing means for mixing the quadrature phase component with the received radio frequency signal and outputting a quadrature phase signal;

means for receiving one of the mixer's phase signals and outputting a phase shifted signal; and

means for combining the phase shifted signal with the phase signal other than the one phase signal to produce an image canceled signal.

8. The receiver of claim 7 wherein the means for outputting a phase shifted signal shifts the one phase signal by ninety degrees in phase.

9. The receiver of claim 7 wherein the ring oscillator comprises four delay cells, an input of each delay cell is coupled to an output of another of the delay cells.

10. The receiver of claim 9 wherein each delay cell delays its input by forty-five degrees and one of the couplings is cross-coupled so that the output of the delay cell is inverted prior to input into another of the delay cells.

11. The receiver of claim 7 wherein the means for outputting a phase shift signal is coupled to the first mixing means.

12. The receiver of claim 7 wherein the first and second mixing means comprises a gilbert cell.

13. A method for canceling an image signal from a received radio frequency signal, the method comprising:

providing a ring oscillator;

producing a radio frequency signal having in-phase and quadrature phase components with the ring oscillator;

mixing the in-phase component and the received radio frequency signal to produce an in-phase signal;

mixing the quadrature phase component and the received radio frequency signal to produce a quadrature phase signal;

shifting a phase of one of the phase signals produced by mixing the components to produce a phase shifted signal; and

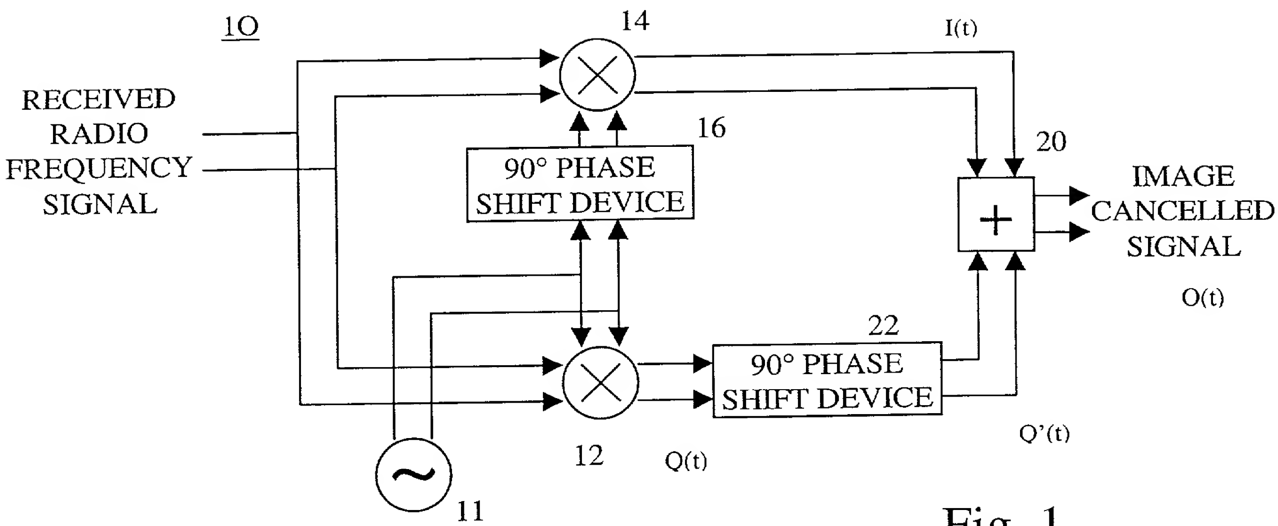
combining the phase shifted signal with the phase signal produced by mixing the components other than the one phase signal to produce an image canceled signal.

14. The method of claim 13 wherein the one phase signal is the quadrature phase signal.

15. The method of claim 13 wherein the phase shifting is by ninety degrees in phase.

ABSTRACT

A ring oscillator produces an in-phase and quadrature phase radio frequency signal. A first mixer mixes the in-phase signal with a received signal. A second mixer mixes the quadrature phase signal with the received signal. A combiner, operatively coupled to the first and second mixers, produces an image cancelled signal.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I(t)
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O(t)
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Q(t)
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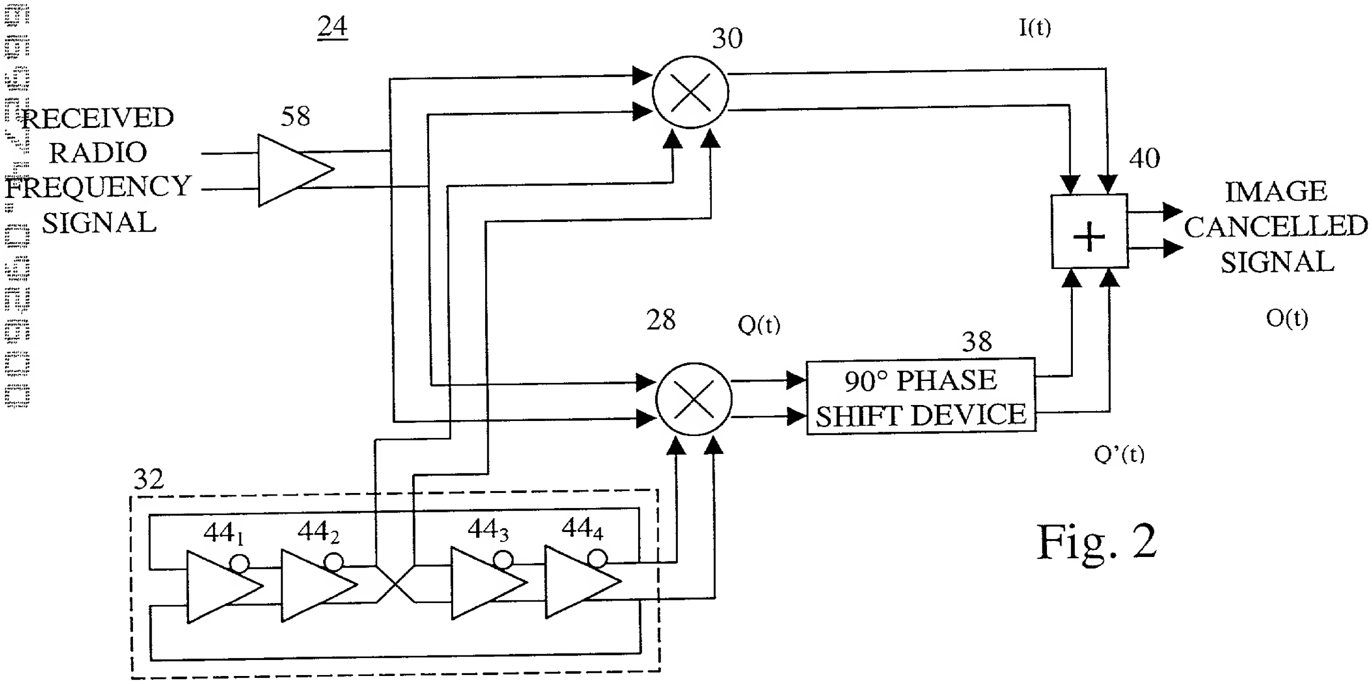
Fig. 1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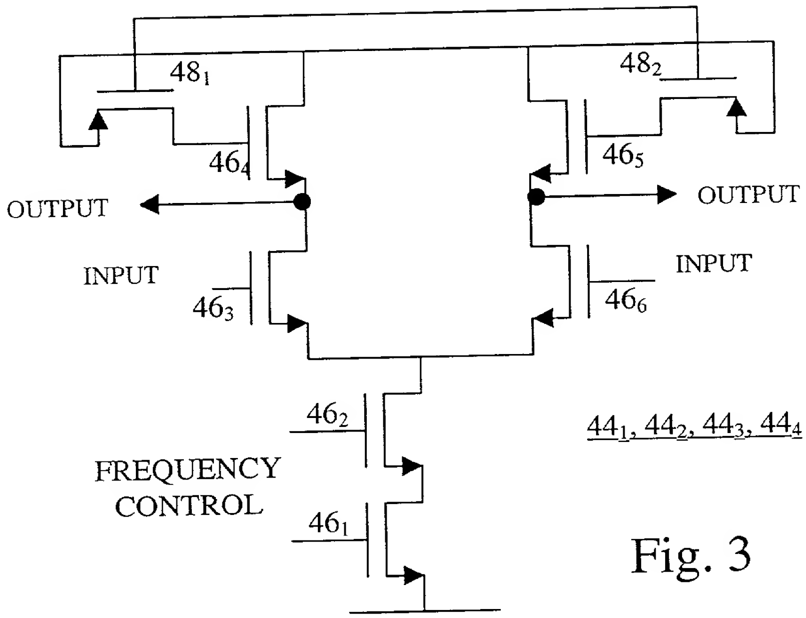
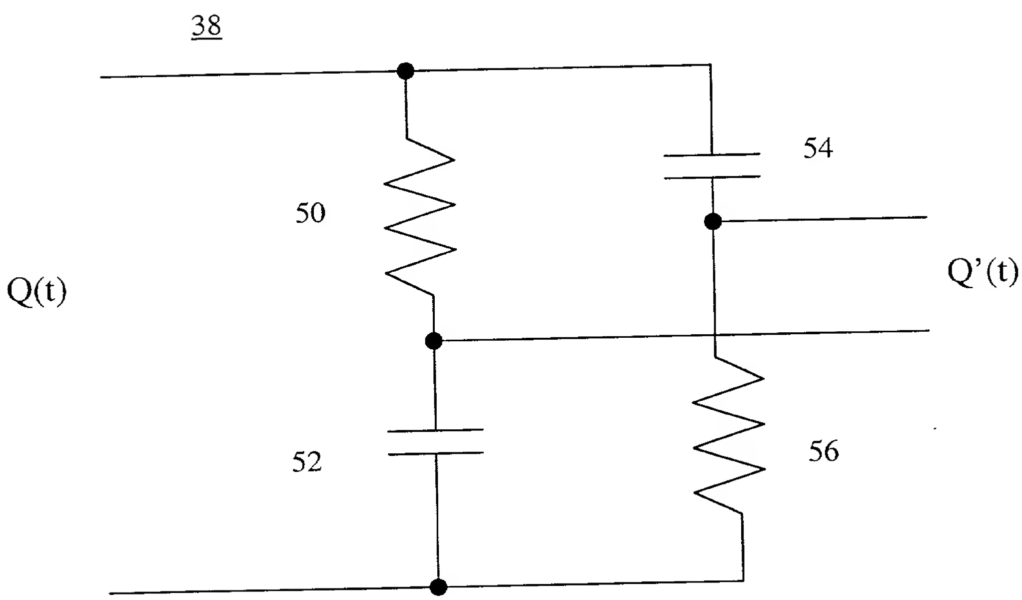
44_1
44_2
44_3
44_4

Fig. 2



48₁
48₂
46₄
46₅
OUTPUT
OUTPUT
INPUT
INPUT
46₃
46₆
46₂
FREQUENCY
CONTROL
46₁
44₁, 44₂, 44₃, 44₄

Fig. 3



38
54
50
Q(t)
Q'(t)
52
56

Fig. 4

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DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☒ Declaration Submitted with Initial Filing OR ☐ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

Attorney Docket Number	ATI-000150BT
First Named Inventor	Feliks Dujmenovic
COMPLETE IF KNOWN	
Application Number	Not Yet Known
Filing Date	Not Yet Known
Group Art Unit	Not Yet Known
Examiner Name	Not Yet Known

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

IMAGE REJECTION MIXING IN WIDEBAND APPLICATIONS

(Title of the Invention)

the specification of which
☐ is attached hereto
OR
☐ was filed on (MM/DD/YYYY) [ ] as United States Application Number or PCT International Application Number [ ] and was amended on (MM/DD/YYYY) [ ] (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	NO
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)

☐ Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

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DECLARATION — Utility or Design Patent Application

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT International application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number *(if applicable)*

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: ☒ Customer Number 25310 → *Place Customer Number Bar Code Label here*
OR
☐ Registered practitioner(s) name/registration number listed below

Name	Registration Number	Name	Registration Number
Namely, the Attorneys of Volpe and Koenig, P.C.			

☐ Additional registered practitioner(s) named on supplemental Registered Practitioner Information sheet PTO/SB/02C attached hereto.

Direct all correspondence to: ☒ Customer Number or Bar Code Label 25310 *OR* ☐ Correspondence address below

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Address					
Address					
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Country		Telephone		Fax	

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any])				Family Name or Surname			
Feliks				Dujmenovic			
Inventor's Signature						Date	[illegible]
Residence: City	Richmond Hill	State	Ontario	Country	Canada	Citizenship	Canada
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☐ Additional inventors are being named on the ____ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto